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Improving Work Stations for Meat and Poultry Inspection

Preface

This report is part of a joint effort by the Agricultural Marketing Service (AMS) and Food Safety and Inspection Service (FSIS) to (1) improve the efficiency of meat and poultry inspection systems and (2) make the working environment for inspection people more comfortable, safe and efficient.

The author wishes to express his appreciation to C.E. Harris, Chief of the Marketing Research Branch, AMS, for his guidance and support in this endeavor. Appreciation is also extended to FSIS personnel of the Industrial Engineering and Ergonomics Branch, the Facilities Standards and Review Branch and the Equipment Standards and Review Branch for their assistance in providing data for this report. Thanks are also due to the many plant personnel and USDA inspectors whose cooperation was so important to the writing of this report.

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Improving Work Stations for Meat and Poultry Inspection

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Summary

This publication reports on a study of meat and poultry inspection facilities and equipment. Beef, swine and poultry plants throughout the United States were visited, and the need for improvements to facilities and equipment for inspection purposes was noted in each type of plant. Appropriate background information on ergonomics and human physical dimensions and limitations was gathered. Drawings and plans for improved beef viscera, hog viscera and poultry inspection stations were prepared. An experimental, prototype off-line beef viscera inspection table was constructed and tested in a number of commercial plants. The tests showed that off-line inspection of beef viscera (1) was possible at speeds as great as 400 head per hour; (2) allowed inspectors more time to perform the inspection procedures; and (3) allowed the inspectors to remain stationary during inspection, eliminating unnecessary walking back and forth along the conveyor line.

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Meat and poultry inspectors safeguard the nation's meat and poultry supply by inspecting each animal before and after slaughter. Animals are checked for any condition or disease that would prevent them from being safely used for human consumption. In addition, the slaughterer's plant, equipment and methods are under constant surveillance in order to maintain high standards of sanitation and food safety. Inspectors are trained federal employees, working in privately owned facilities, and being paid at taxpayers' expense. Increases in population, changes in consumer tastes, and a rise in the number of slaughter plants under federal inspection have increased the workload of inspection. Table 1 shows the relative increases by species of animals processed in U.S. slaughter plants from 1963 to 1985.

Increases in production, plant consolidations, technical innovation, and streamlined inspection procedures have all served to increase the rate at which inspection is performed in the plants. Studies by Wilkes and Stammerjohn [21], Brune [5], and Dotson [8] indicate that stress from the job is an important factor in the lives of many of these inspectors. Responses to this stress, in some instances, included such negative behavior as increased drinking, smoking, arguing, and absenteeism.

Dotson [8] investigated stress among meat and poultry inspectors and identified a number of causes as well as some possible cures. The causes of stress were of both a psychological and physical nature. Psychological pressures resulted from the inspectors' home lives, money problems, and relationships with supervisors and fellow workers. Physical stressors from the job included: ill-fitting equipment, noise, high temperatures, humidity, and the fast pace of the work. Some suggestions for relieving stress included: wearing hearing protection at all times; making improvements in lighting, seating, platforms, and presentation of carcasses; giving control of line speed to inspection personnel; providing more relief "breaks", and improving communication among inspectors, the inspector in charge (IIC), and plant management.

It was thus decided to investigate those stressors with an identifiable physical cause in an effort to determine what improvements could be made.

Table 1. Animals Slaughtered in Federally Inspected Facilities in 1963, 1983 and 1985 [13, 16]

species	1963	1983	1985
Poultry	2,056,575,000	4,492,904,000	4,813,892,000
Cattle	21,662,000	34,816,000	34,765,000
Calves	4,535,000	2,798,000	3,168,000
Hogs	71,577,000	84,762,000	81,974,000
Sheep & Lambs	13,955,000	6,412,000	5,976,000
Goats	197,000	79,000	124,000
Horses	41,000	—	128,000
Total	2,168,542,000	4,621,771,000	4,968,227,000

Procedure

The primary procedure was to identify those problems which were most amenable to solution by making improvements in facility and equipment design. This goal was accomplished by, (1) visiting a number of slaughtering facilities; (2) identifying problems specific to each plant; (3) arriving at generalized solutions that could be used in a number of different plants; and (4) designing particular facilities and equipment to alleviate the problems.

In conjunction with the above steps, a comprehensive literature review was performed. A series of designs, recommendations, and drawings was developed to be used as a guide to the improvement of inspection stations. Finally, selected designs were built and tested under actual field conditions.

Identification of Problems

Site Visits

Slaughter plants were visited in Maryland, Virginia, Alabama, Ohio, Colorado, Texas, and elsewhere. Facilities involved in the slaughter of cattle, hogs, lambs, and chickens were investigated. Less than optimum conditions for inspection personnel were noted in most cases. Inspection facilities were found deficient or below standard in the following general categories: noise, heat and humidity, lighting, floor surfaces, seating, and work heights.

High noise levels were found to exist in nearly every facility visited. Most inspectors wore personal ear protection devices at least some of the time. Such devices reduce noise levels from 10 to 30 db., depending on the type of device and the frequency of the noise. Comfort was a factor in the amount of time these devices were worn. Noise levels of 90 db. were noted routinely in plants checked by Dotson [8]. This noise level is attenuated very little by the concrete and metal construction used in slaughter facilities. Some partitioning and noise isolation was used in the plants, but in general, noise produced in one area of the plant was freely transmitted to other areas.

The temperatures found on the kill floor varied according to station, plant, time of year, and time of day. The amounts of water and steam used for processing, cleaning, and sterilizing not only tended to warm the environment, but also to produce very high humidity levels.

Lighting in all plants surveyed was accomplished with fluorescent tubes. Lighting levels, in most cases, were about 50 footcandles. Some reduction in light levels was observed due to discolored light covers. Some glare from poorly positioned lights and reflections from metal surfaces was also observed.

Floor and walkway surfaces were highly variable both in type and in quality. General walking areas were usually slippery, ordinary concrete. Often there were breaks, curbs, and changes in elevation. Inspection areas were generally, but not always, of a slightly better type of floor surface that included a "gritty" surface coating over concrete. Raised platforms had either expanded steel or concrete surfaces. In one case, platforms with a convex cross section were being used by hog head inspectors. Sloping, uneven surfaces, such as these, cause bad posture and stress for inspectors.

Inspection seating found in plants was limited to that found in poultry processing facilities. Of these, most were homemade steel stools. None were bolted down or otherwise secured to prevent falls. Few had any type of back support. None had foot rests or any contour to the seat.

The working heights of inspectors' equipment is, in most cases, fixed and standard throughout the industry [2]. However, this does not take into consideration the variation in stature among meat inspection personnel. Variations of more than a foot in height among inspectors in a plant were not uncommon. Poultry inspectors, in some cases, had height-adjustable platforms upon which to stand. There did not, however, appear to be any particular criterion used to determine the height of platforms. Shorter inspectors were observed keeping the platform at a low height and taller inspectors would sometimes keep them raised to the maximum height. Dotson[8] also reported this phenomenon.

Design Suggestions

Environment

The factors that affect the thermal environment of meat and poultry inspectors are air temperature, humidity, air velocity, clothing, level of activity, and radiant energy sources.

Increasing levels of temperature and humidity decrease the body's ability to rid itself of excess heat. Higher air movement increases convective and evaporative cooling. Clothing acts as an insulator and, in some cases, as a vapor barrier. The type of work and the amount of effort by an individual greatly affect the amount of heat generated in the body. Radiant heat sources add significantly to the thermal load on the individual, and this effect is not directly measurable by air temperature.

Measuring the quality of the thermal environment is difficult, because of the numerous factors involved. ASHRAE [3] and Esmay [9] contain a number of indices that take into account temperature, humidity, and radiant heating. The equivalent temperature [3], temperature humidity index [9], black globe temperature, and wet bulb globe temperature are examples of such indices. The temperature humidity index (THI) is calculated from equation 1 with values easily measured in the field. Table 2 shows some temperature and relative humidity combinations and their corresponding THI's. A THI of 70 means that 10% of the general population is uncomfortable, 75 means that 50% is uncomfortable, and 79 or greater indicates that nearly everyone is uncomfortable.

[2] Heights and construction data for work stations are contained in: U.S. Inspected Meat and Poultry Packing Plants, a Guide to Construction and Layout. Agricultural Handbook 570 [15].

$$THI=(0.55T_{db})+(0.2T_{dp})+17.5$$ <eq.1>

where: THI=temperature humidity index, dimensionless
T_{db}=dry bulb temperature,F°
T_{dp}=dew point temperature,F°

Table 2. Equivalent Temperature and Relative Humidity for THI's

THI	Temperature (°F)	Relative Humidity (%)
70	70°	100
10% of pop. is	75°	52
uncomfortable	80°	27
75	75°	100
50% of pop. is	80°	66
uncomfortable	85°	35
79	85°	70
100% of pop. is	90°	37
uncomfortable	95°	19
	100°	10

The THI is thus an effective way to measure the comfort level in meat and poultry plants. It can be used to evaluate temperature requirements, ventilation rates, and the like without relying strictly on temperature.

The effect of heat on worker performance and safety has been documented for more than 50 years. Vernon and Bedford [20] showed:

Rest breaks required by heavy laborers increased markedly at temperatures above 75° F;

Accidents among workers were much more common at elevated temperatures;

Workers over 40 were particularly susceptible to injury at elevated temperatures.

Recommendation

It is suggested that temperatures at inspectors' work stations in meat and poultry plants be maintained at or below 80°F and the THI at or below 70. These requirements are particularly necessary because of the high humidity found in most slaughter plants.

Lighting

The type, level, and quality of lighting affects very strongly how safely, effectively, and comfortably a worker can perform his job. Lighting is usually defined as being direct or indirect. Direct lighting emanates directly from the light source onto the object being viewed. There is often a large contrast between the area being lit and the surrounding areas. Indirect lighting is more diffuse in that light is scattered about the room and reflected from a number of sources. Consequently the room is more evenly illuminated. This reduces the amount of contrast and the number of shadows.

Lighting Levels

The lighting needs of meat and poultry inspectors vary according to the individual and the work being performed. Two individuals performing identical tasks may indeed require different levels of illumination. Kaufman [10] suggests that age is an important factor in this regard. As people get older, the minimum lighting level required to perform a task increases. Also, published minimum lighting levels have been increasing over time. This is a response to both the availability of improved lighting equipment and the realization by workers that increased lighting reduces the subtle stress associated with eye strain. The minimum lighting levels shown in table 3 are minimum, not optimum, levels.

Table 3. Published Minimum Lighting Levels for Inspection Tasks

Task	Lighting Level (footcandles)	Reference
General meat inspection	50	(7)
MTI viscera inspection	150	(6)
NELS poultry inspection	200	(7)
Reinspection of poultry	200	(7)
Poultry grading	100	(2)
Industrial inspection (rated by degree of difficulty)		
ordinary	50	(1)
difficult	100	(1)
highly difficult	200	(1)
very difficult	500	(1)
most difficult	1000	(1)

Recommendation

It is suggested that a minimum general lighting level of approximately 100 footcandles be available at all inspection stations.

Provision should also be made for some additional local lighting (total of 200 footcandles or more) that could be controlled and adjusted individually by the inspector.

Lighting Quality

Lighting levels alone do not specify adequate lighting to perform an inspection procedure. The light must be of the proper spectral makeup or quality. Light quality is often defined in terms of color temperature; that is, the absolute temperature of a body producing the predominant color of light of the light source. Table 4 contains various light sources and their equivalent color temperatures.

Table 4. Color Temperature of Some Light Sources [10]

Light Source	Color Temperature (Kelvin)
blue sky	10,000-20,000
overcast sky	5,000 -7,500
"cool daylight" fluorescent	6,750
direct sunlight	5,000
"white" fluorescent	4,300
carbon arc lamp	3,750
photo flash	3,200
incandescent bulb	2,400 -3,000
"warm white" fluorescent	2,900
candle	1,900

Table 4 shows the wide variation in color temperatures, especially for various types of natural light. The problem with color temperature as a measure of lighting quality is that light from two different sources, even those having the same color temperature, is not exactly the same. Natural lighting tends to have a wider, more complete representation of light wavelengths. Artificial lighting tends to emanate light in a few narrow bands that can distort the color of objects viewed in its light. Thus, using color temperature as the sole means of determining light quality is not correct.

Another measure of lighting quality is the color rendering index [10]. This index is a number, ranging from 0 to 100 that indicates the relative chromatic shift of some 8 color standards when viewed under the test lamp. A color rendering index of 100 would indicate a light source that does not alter the color of the color standards at all. By regulation [7], NELS poultry inspection must be performed under lamps that have a minimum color rendering index of 85.

Kaufman [10] discussed the lighting sources USDA developed for use in cotton classing. The idea was to imitate natural light of 7500°K color temperature. Early efforts consisted of filtered incandescent lamps, and later ones used custom fluorescent tubes. The incandescent lights probably produced a better approximation of natural light, but cost more to operate, generated heat, and had to be replaced more often than the fluorescent.

A lighting task force was formed [17] to determine what the needs and possible solutions were for lighting. A contractor was hired who had experience in developing fluorescent lamps with custom-tailored output characteristics. By varying the makeup of the various phosphors, metals and gases used in building the tubes, custom spectral outputs may be produced. The problem involves as much determining what that output should be as actually constructing the lamps. Tests were to be performed in an effort to determine the theoretically perfect spectral mix for meat and poultry inspection.

Until this research is completed, more ordinary light sources must be used. Fluorescent lamps are most often used for general lighting. A combination of the best characteristics of "cool white" or "cool daylight" fluorescent lamps and incandescent lights, such as those found in good-quality drafting lamps, may be the best interim solution.

Recommendation

Use a combination of "cool" fluorescent and "warm" incandescent light sources to provide a balanced color output for meat and poultry inspection until an optimumly designed inspection lamp is developed.

Lighting Fixtures

Light fixtures, or "luminaires" as they are sometimes called, hold the lamp in position, protect it from physical damage, and direct the light in the proper direction.

Workers and food products must both be protected from the dangers of broken glass. This necessitates the use of covers on all fixtures. In addition, covers generally act to diffuse light, prevent glare, and illuminate the work area as evenly as possible. Lamps used for general lighting purposes are often quite powerful and can be "blinding" without diffusers or diffusing covers.

As opposed to general area lighting, spot lighting uses a fairly intense source of light and concentrates it on a smaller area. Often incandescent lamps are used for this purpose. Light housings for such fixtures are shaped to concentrate the light in a small area instead of spreading it about. Covers, when used, are mainly for mechanical protection of the lamp itself since diffusion is not especially desired. Glare is a danger when using spot lighting.

Glare

Glare is an unpleasant effect on the human eye associated with the presence of light in greatly different intensities. It can be caused by intense, unshielded light sources within the view of the inspector or reflections from a shiny surface. Prevention of glare is of primary importance in the improvement of the visual work area.

Glare prevention

The prevention of glare can be accomplished in a number of ways:

(1) Proper selection of lamp type;
(2) Placement of light sources high above the workers;
(3) Use of shielded fixtures;
(4) Use of diffusers;
(5) Reduction of the number and size of reflecting surfaces.

Lamps of higher power ratings, 240 watts and above, should usually not be of the incandescent type. Incandescent lamps are rather intense point sources of light and thus tend to be glare producing in themselves. Any bright source of light produces glare, especially if it is in the line of sight of the worker. By placing most fixtures high above and behind workers, this direct type of glare can be reduced. For lamps which for one reason or another cannot be placed completely out of the workers' view, the use of shielded fixtures is of the greatest importance. Stray bits of leaking light can disturb, annoy, and even harm a worker. Thus, shielding of all lamps is recommended. Diffusing grates, covers, or coatings cause the light to be more dispersed and far less intense and so reduce glare. Light reflected from shiny metal, glass, and some painted surfaces can cause glare. Repositioning the worker, repainting, non glare coatings, and screens are some possible solutions to reflected-light glare problems. Since painted surfaces are not allowed for most situations in establishments, repositioning of lights and workers is the most viable solution to this type of problem.

Floor Surfaces

Acceptable quality floors have these essential properties:

(1) Non slippery;
(2) Well drained;
(3) Free of obstructions;
(4) Acid resistant.

Falls are a leading cause of accidents among meat and poultry inspectors. Slippery floors are probably one of the leading causes of these falls. Slaughterhouse floors are often covered with water, blood, and grease. Obstructions, cracks, and changes in elevation are common.

It is possible to have floors that are not slippery if they are constructed of the proper materials and then maintained in the proper condition. Flooring may be constructed of brick, metal, concrete, or tile. All four materials can be quite slippery if wet and greasy. Metal floors, constructed of expanded steel, are adequate for inspection stations on raised platforms. Concrete, on which a surface coating of emery, iron filings or other abrasive product has been added, is also a good, safe surface. Extending the use of these surface coatings from the inspection area to the pathways used by inspectors to travel from office to station will greatly increase safety. Handrails in strategic locations such as stairways and at the edges of inspection areas may help prevent falls.

Floors must be well drained. A normal slope of about 1/4 inch per linear foot must be maintained in most areas in order to keep excess water from remaining underfoot. One drain for each 400 square feet of area is necessary as well.

Acid resistance is important for flooring in order to prevent the premature wear, unevenness, and cracks that will eventually result. Acids from fat tend to attack ordinary concrete and mortar. As time goes on the cement in the concrete and mortar is dissolved, allowing the aggregate to work loose and tiles to come up. Acid-resistant materials include special acid-resistant concrete and mortar formulations. These should always be used in new construction as well as in remodeling.

Obstructions on and near the floor can cause tripping and falls. This is particularly true of the excess numbers of curbs, steps, pipe fittings, cracks and unevenness that are often found in the floor. Any obstruction that cannot be readily repaired or removed should be marked clearly.

Ergonomics

Ergonomics, or human factors engineering, is the field which applies knowledge of the limitations, preferences and abilities of human beings to the design problem. Schmidtke [12] states that the main goals of this field are:

(1) "To safeguard the health of a person";
(2) "To prevent him from overload";
(3) "To encourage lifelong development of his personality";
(4) "To facilitate safe employment conditions, thereby protecting him and other people from injury"; and finally
(5) "To warrant a display of performance meeting economic requirements" (i.e., increase work output).

One important area in human factors work is fitting equipment to the people in all their various sizes and shapes. For that purpose, measurements of the human body have been made. The data are ranked and classified in terms of percentiles. For design of facilities and equipment the 5th and 95th percentile data are usually chosen. Since women are both an ever-increasing portion of the workforce and statistically somewhat smaller in size, the 5th percentile data are often taken from female data, and 95th percentile taken from male data. This gives a somewhat wider range to the result. The body dimension data used for this report came mainly from NASA data projected for "1985 Americans" [11].

Seating

Inspections performed in the seated mode in meat and poultry slaughter facilities have heretofore been confined mainly to poultry inspection. The reasons for this are many, but it is probable that the main reason is the lack of heavy physical effort associated with current poultry inspection procedures. Heavy physical effort is also being reduced in red meat plants as establishments begin to perform more cutting and presentation functions previously done by inspectors. This means that less and less frequently will inspectors need to lift, slice, and pull large heavy organs. Inspection itself seems to be heading toward more of a visual and less of a hands on approach. This lightening of the physical effort encourages sitting.

In the past, supervisors were often negative about seeing their employees seated during work hours. The feeling seemed to be that if workers were relaxed and less stressed while doing their jobs, then they were not working as hard as possible. So far this has not been proven. Most managers now realize that reduction of stress, whether physical or mental, improves the work environment and leads to increased productivity.

The conditions that must exist for use of chairs by inspectors are as follows:

(1) The inspector must be able to see the product when seated.
(2) If it is necessary to handle the product during inspection, then it must be within easy and safe reach.
(3) The inspection procedure must not require a large amount of physical effort.
(4) There must be sufficient room in which to install the chair.

In order to select chairs for use by inspectors, some characteristics of good seating must be considered:

(1) Height adjustability
(2) Eye point[3] adjusted to product height
(3) Proper back support
(4) Proper seat shape
(5) Foot rests
(6) Compliance with sanitation requirements
(7) Compliance with safety requirements

Table 5. Eye Heights of Adult Americans [11]

Group (percentile,gender)	Sitting (in.)	Standing (in.)
5th female	27.4	55.4
95th male	34.1	69.4

Because people are in numerous sizes and shapes, it is necessary to have chairs that will, with some reasonable degree of comfort, fit most of the people that sit in them. This means that height ajustability must be built in. Since inspectors change position periodically during their shift of duty, the adjustment controls must be fast and easy to operate. Adjustment of heights may be accomplished by moving either the chair, or the platform on which the chair rests, up and down.

Adjusting the inspector's eye point to that of the product being inspected is again a matter of being able to move the inspector up and down until his eyes and the product line up.

Table 6. Heights of Products in Program Establishments [15]

Species	Part	Distance (in.)
cattle	head	54
	tongue	60
	viscera	34
hog	head	60
	viscera	34
poultry	carcass	48
	inside/viscera	52
(NELS)	viscera	60(minimum)

[3] Eyepoint is the height of the eye above a reference point, usually the chair seat.

Results

Cattle Inspection

Inspection of beef cattle for slaughter consists of both antemortem and postmortem inspections. The inspection of the live animal usually takes place in a holding pen before slaughter. This is mainly a visual inspection to ensure that only live, healthy, and undamaged livestock are slaughtered. Postmortem inspection is more involved and consists of head, viscera, and carcass inspections of each animal. Viscera inspection is the area that was chosen for the most intense study.

Description of Present Cattle Viscera Inspection.

In the higher speed cattle slaughter plants, a powered overhead trolley conveyor system moves the carcasses from point to point within the plant. During evisceration, a plant employee opens the body cavity over a long, stainless steel conveyor. As the carcass is opened, the viscera drops onto the conveyor, which transports it to the Government inspector. Proper placement of viscera normally means that the heart and lungs ("pluck") are on one side of the conveyor, the liver and spleen on the other side, and the paunch in the middle.

Viscera inspection may be performed by one or more inspectors, depending on the rate of kill and the inspection system used. Commonly one or more inspectors will inspect the heart and lungs while another will look at the liver and spleen.

An inspector will normally (1) observe the carcass; (2) observe the viscera set as a whole; (3) grasp the pluck (or liver); and (4) perform the required incisions, palpations, and visual inspections. These functions are performed while the product is moving, necessitating holding the product in place or moving along with it. Walking along with the product forces the inspector to walk back to his/her original position to begin the inspection of the next organ set.

Current inspection facilities for viscera inspectors include a platform, 3 feet by 8 feet, raised 6 inches above the floor. There is also a lavatory, a knife sterilizer, and a place for a stamp and pad. Controls for turning the line off and on are normally placed above the work area within easy reach. The flight-top conveyor is set at a height of 34 inches above the inspector's platform. All controls, heights, and platforms are fixed with no provision for adjusting them to suit individual dimensions or preferences.

The time allowed for an inspector to perform his/her task depends mainly on the rate of slaughter. The carcasses and their corresponding viscera sets are spaced 8 feet apart, and each inspector's work area is also 8 feet long. Thus, the time between the arrival of viscera sets is given by equation 2 as:

time = 3600(sec./hour) /kill rate(head/hour) <eq.2>

Table 7 uses equation 2 to give the approximate time available for pluck inspection at various slaughter rates.

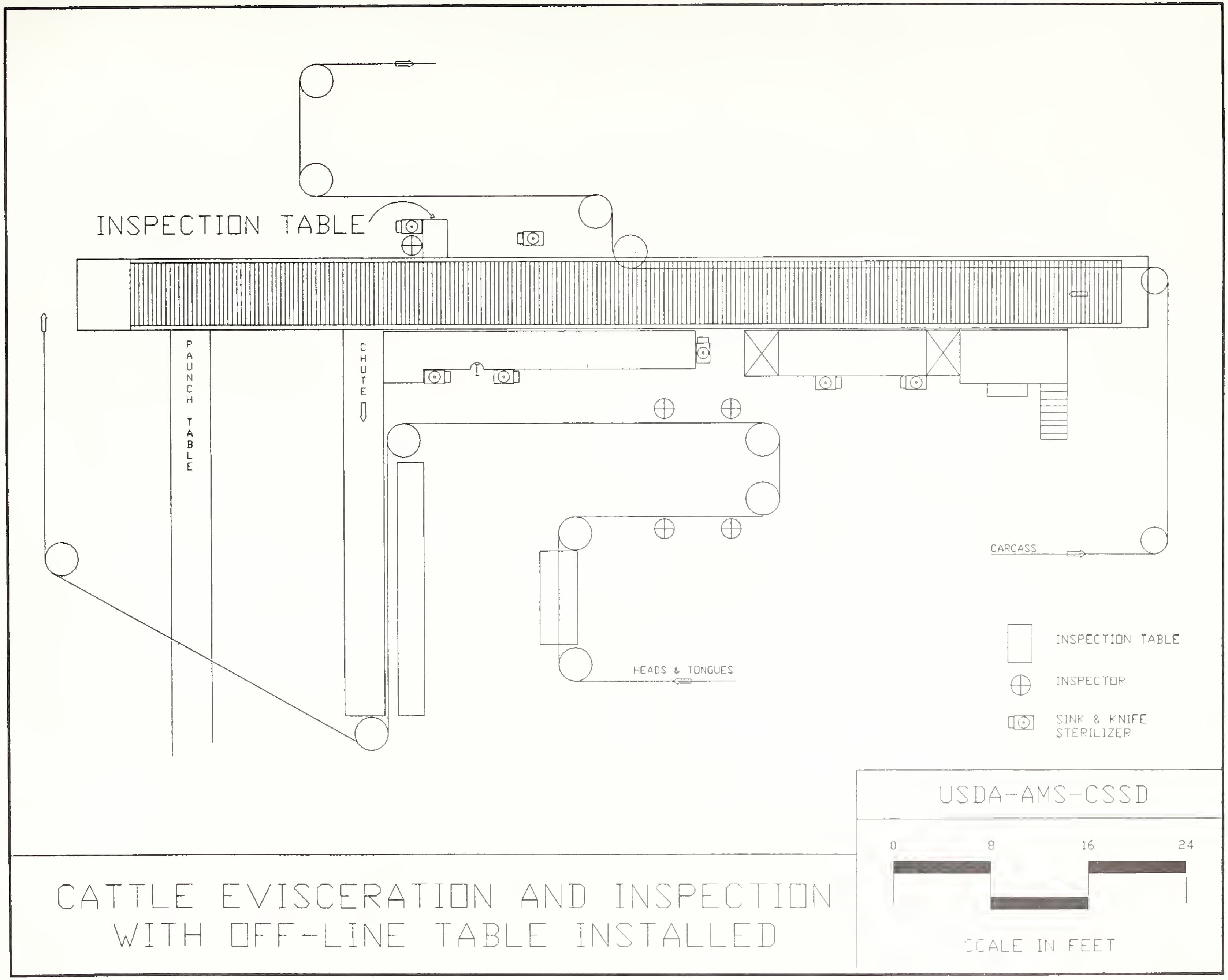
Table 7. Time Available for Pluck Inspection

Slaughter Rate (head-per-hour)	Time Between Pluck Arrivals (sec.)
120	30
180	20
240	15
300	12
360	10
400	9

For a plant processing 360 head per hour, this allows 10 seconds between viscera set arrivals. If pluck or liver inspection is not completed within this timeframe, the inspector must employ some coping strategy. This would mean sliding the pluck past the paunch or lifting it over it. In either case, it is a difficult operation and occasionally leads to contamination of otherwise edible product.

Figure 1 shows a fairly typical evisceration line layout. Because most plants employ the single evisceration line arrangements shown, adding additional inspectors does not increase the time available for inspectors to perform their job. It does however increase the amount of time between inspections.

Figure 1. Layout of Beef Viscera Inspection Line



Improved Beef Viscera Inspection Equipment

In order to improve the comfort, safety, and efficiency of viscera inspectors, an off-line beef pluck and liver inspection table was conceived. Its basic features included a stationary work surface and self-cleaning sanitary design. The idea was to provide the inspector with a compact work station where the plucks and livers could be inspected while both the product and the inspector remained stationary. Figure 1 shows a typical beef evisceration line with the off-line table installed.

It was thought that off-line inspection in higher speed (300 head per hour and above) plants would also allow the inspectors more time in which to perform inspections. As was previously discussed, the amount of time allowed for the inspection procedure is somewhat limited by speed and the time between carcasses. The example given was 10 seconds between the arrival of carcasses at a slaughter rate of 360 head per hour. Table 8 gives the calculated values for the time theoretically available for performing inspections on beef plucks with either the present on-line procedure or a proposed off-line table method. The actual amount of time to perform the inspection procedure varies considerably from the values listed, but these values do give an indication of the benefits of using an off-line stationary pluck inspection system.

Beef Pluck Inspection Table

Figure 2 presents the first prototype off-line beef viscera inspection table. The table was constructed of stainless steel and had a 26 x 34-inch working surface with a raised lip on three sides. The side of the table adjacent to the flight-top inspection table was left open in order to allow the pluck to be moved between the table and the conveyor. The surface of the table was sloped 0.5-inch toward the open end to allow for drainage. A gap between the conveyor and the table, equipped with a drip edge, allowed the water to flow toward the floor drains and not back onto the conveyor. The table legs were equipped with feet that could be adjusted approximately 12 inches in height and could be bolted to the floor. A knife box for sterilizing the inspectors' knives with water at 82° C (180° F) and a handwash lavatory gooseneck were provided. A 0.5-inch pipe perforated with 1/8-inch holes served as a spray to sanitize the top surface with hot or cold water controlled by two knee-operated valves. A small storage area was provided for storage of stamp, pad, and counter.

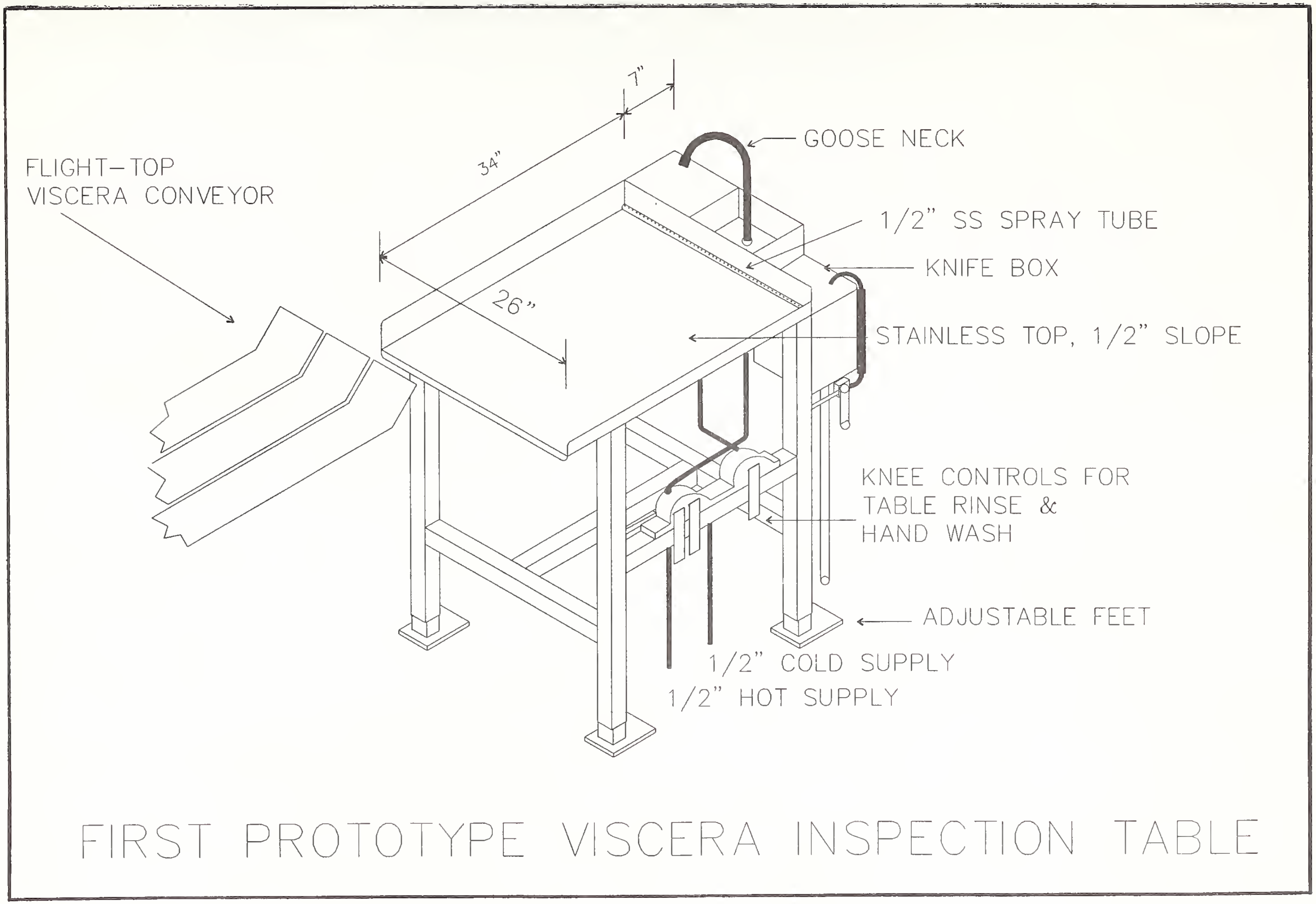
Table 8.

Comparison of Theoretical Inspection Time Using On-Line and Off-Line Inspection

Kill Rate head / hour	Time (sec.) w/out table	Time (sec.) with table	No.Inspectors [4]
120	30	30	1
180	20	40	2
240	15	30	2
300	12	24	2
360	10	30	3
400	9	27	3

[4] Inspector manning is for traditional inspection system.

Figure 2. First Prototype Off-Line Viscera Inspection Table



Test of First Prototype Pluck Table

As part of a joint FSIS/AMS project to improve work stations for meat and poultry inspectors, the experimental beef viscera inspection table was tested by the U.S. Department of Agriculture in a small cattle slaughter plant in Ohio. Cattle are slaughtered at a rate of approximately 42 head per hour in this plant. The table was installed by plant personnel one evening before the day shift began. The first use by FSIS inspectors occurred at about 6:30 AM the following day. Test usage continued for the next 7 days.

The purpose of this test was to determine the feasibility of inspecting beef viscera (heart, lungs, liver, and spleen) off-line. The current practice is to inspect these organs on a moving conveyor, referred to as a "flight-top table."

The table surface had a built-in slope of 0.5-inch downward toward the open side. Additional slope could be created by shortening the front legs with built-in adjusters. When adjusted too far, the wet, slippery organs slid off the table and back onto the conveyor. Adjusting the slope so as to maintain the 0.5-inch slope reduced this problem. The table was set up so that the inspector faced downstream (i.e., away from the upcoming carcasses and viscera). This meant that the left hand was used to grasp the organ and move it onto the table. During the test, inspectors used two different methods for inspecting viscera. Some preferred having the heart-lungs and liver-spleen on the table simultaneously, while others preferred performing the inspections separately. Inspecting both groups of organs together interfered with the drainage of water from the table. Some splashing resulted, and the inspectors' clothing occasionally got wet. The separate inspection method, which is similar to that in high-volume plants, did not result in splashing.

Inspectors faced downstream and some had difficulty in maintaining visual contact with the carcass from which the viscera were taken. Facing in this direction also made it necessary for inspectors to turn and reach behind them when removing organs from the conveyor.

After completing an inspection, the organs were gently shoved back off the table and onto the conveyor. The use of excessive force resulted in a liver or heart sliding across the conveyor, up the opposite side, and onto the floor. This occurred a few times until inspectors became aware of how little effort was actually required to get the organs back onto the conveyor. An additional difficulty in this area resulted from the presence of unsanitary material on the flight-top conveyor. Since edible product must not become contaminated, it is critical to place the organs on a clean spot on the conveyor after inspection. Contamination causes economic loss to the establishment, while an inspector waiting for a clean spot on a conveyor loses efficiency.

Sanitizing the table surface was accomplished by spraying 180° F water from a spray pipe located at one end of the table. The spray tube was a piece of stainless steel pipe, with 1/8-inch holes drilled in it, mounted with a 0.5-inch clearance between it and the table lip. As pointed out by a number of people, this clearance was too small to allow proper cleaning behind it. Because of a slight "crown" or high spot in the center part of the table, water did not flow evenly across the entire surface.

In order to clean the table properly, some inspectors placed their hands in the hot water and "swirled it around." This was uncomfortable for the inspectors, and the procedure took far too much time to perform.

In between washing the surface with the hot rinse, the surface was also wetted by a continuous trickle of cold water from the spray tube. The idea was to maintain a wet surface which blood would not adhere to. Again, because of the crown in the table surface, water did not flow evenly across the surface. Also, the cold water trickling across the surface cooled the metal sufficiently for tallow to congeal. The tallow could be prevented from setting on the cold metal surface by using a warm (rather than cold) water trickle. Flow to the trickle tube was controlled by a small ball valve. Ball valves are more properly used to turn water off and on (that is completely on or completely off). They are not properly used to regulate or throttle a fluid flow. This function is normally given to needle valves, which are designed for this type of service.

A gooseneck type lavatory was provided for hand washing. Since the wastewater from the lavatory drained over the table surface, it was a possible source of contamination. Hand rinse water from handling condemned organs could remain on the table unless the inspector remembered to sanitize the table with the hot water flush. Since most hand rinsing and washing by inspectors is done with the knife in hand, the 8-inch clearance between gooseneck and table was insufficient for convenient use. The sanitation problem is perhaps best handled by relocating the hand wash function to a separately drained area. This could be a standard freestanding lavatory situated to one side.

A small gap between the inspection table and the flight-top conveyor allowed waste water to run off the table without spilling onto the flight-top. Additionally, this gap was necessary to maintain sufficient clearance between the conveyor and the table so that the flights did not come into contact with the table and destroy it. Because of the temporary nature of the installation, the table was not bolted to the floor. A temporary clamp was fashioned so that the table was held in position away from the moving flights.

Inspection personnel using the table varied in height from approximately 62 to 74 inches. The table height of 34 inches was too high for convenient use by the shortest inspector, but was fairly comfortable for taller personnel. This pointed out the urgent need to add an adjustable platform for use by inspectors of various heights. A 1-inch-thick mat was laid on the floor, which did raise the shorter inspectors somewhat. However, the mat was insufficient to lower the working height of the 62-inch inspector to a comfortable level. In addition, the mat was slippery due to its plastic over metal construction.

Lighting in this plant was provided by cool white fluorescent tubes. No measurements of illumination levels were made; however, they appeared to be in line with the current definition of "adequate" lighting. Some glare from metal surfaces was noted. No complaints about lighting were received from inspectors when asked.

Comments from inspection personnel were both positive and negative. Nearly all of the problems identified in this report were first noted by the inspectors themselves. Besides the deficiencies already noted, some inspectors suggested that the inspection procedure took longer when done on the table than on the conveyor.

Carcasses were being processed at 42 head per hour, with approximately 1.4 minutes between the arrival of each set of viscera. The flight-top table was moving at approximately 13.7 feet per minute. This slow speed allowed more than adequate time for inspection, regardless of the method used. Using the table for inspection of both heart-lungs and liver-spleen, actual inspection time ranged from 0.55 to 0.75 minute (Table 9). No effort was made to determine the minimum time needed for inspection.

Table 9. Preliminary Test of Viscera Inspection Table

Slaughter Rate	42 head per hour
Conveyor Speed	13.7 feet per minute
Inspection Time	0.55-0.75 minutes

The test showed that viscera inspection could be performed off-line on a table of this type. Since line speeds (42 head per hour) did not approach those found in the newest high-speed facilities (400 head per hour), it was not possible to predict how well the table would serve at the higher kill rates. However, since no major difficulties were encountered, it was concluded that further tests should be performed at these higher rates. It was also concluded that improvements should be made in the design of the table to eliminate tallow build up.

Table Modifications

The experimental table was returned and modified in a commercial machine shop by altering the top to a mild V shape. This was accomplished by removing the top surface, bending it to have a 1/2-inch slope from the sides to a line in the center, and welding it back in place. The sanitary spray pipe was removed and two drilled pieces of 1-inch square stainless tubing substituted. This modification was made to improve the distribution of the cleaning water over the table's surface. It also served to remove an area behind the spray pipe where grease and particles of meat could build up. The gooseneck lavatory and its associated knee controls were also removed. The plumbing was altered by adding a mixing valve so that warm water would trickle over the table surface instead of cold. This was done in an effort to reduce the tallow buildup noted in the previous test. An additional knee control was added in order to allow the table surface to be rinsed with cold water as well as hot.

Test of Second Prototype Inspection Table

A large cattle slaughter plant in Colorado was chosen as the second test location. Cattle are slaughtered at a rate of 400 head per hour in this plant. The table was installed by the plant on a Thursday afternoon. The first use by FSIS inspectors occurred at about 7:00 the following morning. Test usage continued until approximately 2:00 that same day. Additional testing took place on the following Tuesday, after some minor modifications to the table were performed on site.

The purpose of this test was to determine the feasibility of high-speed inspection of beef viscera (heart, lungs, liver, spleen) off-line. Two knee-activated valves controlled the flow of water to spray tubes for surface cleaning and sanitizing. A knife sterilizer and a compartment for storing a stamp and pad were also provided. A separate sink for hand washing was located adjacent to the stationary table. The table was set up so that the inspector faced upstream (that is, toward the oncoming carcasses and viscera). This meant that the left hand was used to grasp the organ and move it onto the table.

During the test, inspectors used two different methods for inspecting viscera. In one case, the cuts necessary to open the hearts were performed by plant personnel previous to examination by the inspector. The other case was the more traditional system where all cuts were performed by the inspectors themselves. All tests were done during heart and lung (pluck) inspection only. In previous tests, livers as well as plucks were inspected on the experimental table.

Inspection personnel on the viscera inspection table included three pluck inspectors, two liver inspectors, one inspector for paunch/inedible, and one rail inspector (kidney/inside). Only one position, the first pluck inspection, used the off-line table.

The inspector faced upstream, and being first in line, had little difficulty in identifying every third pluck that he/she was to remove from the conveyor. The inspector grasped the pluck with the left hand, pulled it onto the side table, performed the inspection procedure, stamped it as necessary, located an open position on the conveyor, and placed the pluck back on the conveyor. During the time the pluck was on the side table, another viscera set would usually pass by the inspection station. This caused confusion to inspectors working in the conventional manner further down the line.

Since the new "streamlined" inspection system was being used, there was further confusion about identity because the establishment personnel opened the hearts. Previously, an unopened heart was an uninspected heart.

After completing an inspection, the pluck was gently shoved back off the table and onto the conveyor. Unless the organ was carefully placed, it would occasionally become contaminated with fecal material on the conveyor.

Sanitizing the table surface was accomplished by spraying 180° F water from two spray tubes located in the sides of the table. The spray tubes were pieces of stainless steel square tubing, with 1/8-inch holes drilled in them. Since the table surface had a slightly "vee" shaped cross section, water flowed towards the center of the table. In addition, it had a 0.5-inch slope in the direction of the open side. Adequate water coverage and drainage of the table occurred with this configuration.

In between washing the surface with the hot rinse, the surface was also wetted by a continuous trickle of warm water from the spray tubes. This was done to maintain a wet surface to which neither blood nor tallow would adhere. The trickle was controlled by two small needle valves that varied the amount of hot and cold water so as to maintain a desired flow rate and final temperature. One problem not addressed in previous testing was the temperature of the sanitizing spray as modified by the trickle water. Because of the way the plumbing was designed, the trickle water continued to flow through the tubes at all times. This included the time during which the sanitizing spray was operated. Thus, a small amount of warm water from the trickle system mixed with it and lowered the temperature of the sanitizing spray. The exact value of this temperature drop was unknown because temperature measurements were not taken.

A freestanding sink, adjacent to the inspection table, was used for hand washing. Knife sterilization was performed on either the sterilizer attached to the back of the inspection table or the sterilizer attached to the sink. Neither hand washing nor knife sterilization was completely satisfactory with the setup noted above. The sink was one step farther away from the table than was necessary. The sink used standard floor pedals. With the table using knee controls, and the sink using foot pedals, the inspectors were prone to make mistakes in using one or the other until they got used to them. The pedal problems were further complicated by a stand brought in to match the height of the inspector to the table. Inspectors had to step down off the stand in order to operate the pedals. This added extra time and effort to the inspection procedure. Hand washing is best handled by locating the hand wash function at a standard freestanding lavatory situated to one side of the pluck table, as was used in this test, and making all controls standard.

A small gap between the inspection table and the flight-top conveyor allowed waste water to run off the table without spilling onto the flight-top. Waste water from the table was allowed to run onto the floor. Unlike previous tests, no shield to protect inspectors from splashing water was installed. This was unfortunate because the shield was needed. Additionally, this gap was necessary for maintaining sufficient clearance between the conveyor and the table so that the flights did not come into contact with the table and destroy it. Despite the temporary nature of the installation, the table was bolted to the floor.

Inspection personnel using the table varied in height from approximately 67 to 76 inches. This contrasted sharply with the 62- to 74-inch heights noted during a previous test. The table height of 34 inches was again too high for convenient use by many inspectors. This pointed out the urgent need to add an adjustable platform for use by inspectors of various heights. A 2-inch-thick mat was laid on the floor. This did assist the shorter inspectors somewhat. It was, however, a compromise. A fully adjustable platform that would allow the user to easily adjust his or her working height was needed.

Lighting in this plant was provided by cool white fluorescent tubes. No measurements of illumination levels were made; however, they appeared to be in line with the current definition of "adequate" lighting. Some glare from metal surfaces was noted. No complaints about lighting were received from inspectors when asked. However, the overhead fixtures were placed directly above the flight-top conveyor, not above the side mounted table. A few shadows and a slight diminishment in illumination were observed, so an additional fluorescent light was installed above the work table to provide greater illumination over the entire work area.

Comments from inspection personnel were mixed. Nearly all of the problems identified in this report were first noted by the inspectors themselves. Besides those already stated, some inspectors suggested that the inspection procedure took longer when done on the table rather than on the conveyor. Carcasses were being processed at 400 head per hour, with approximately 9 seconds between the arrival of each set of viscera. The flight-top table was moving at approximately 53.3 feet per minute. This high-speed barely allowed adequate time for inspection, regardless of the method used.

While using the table, actual inspection time ranged from 15 to 19.2 seconds. This, again, was for inspection of only the heart and lungs. The heart was opened by establishment personnel, and one viscera set was allowed to go by before replacing the pluck on the conveyor.

Table 10 gives the average raw times for performing inspections in the 400 head/hour plant. Raw times were taken for inspectors using the table and using the moving conveyor. These data show more time was required for inspections using the experimental table than the moving conveyor. However, raw times do not reflect an allowance for walking time or for the pace of the work. At high speeds, inspectors on the flight-top conveyor must walk along with the organ to inspect it. Walking time is added to the raw time to calculate the total time required to perform the inspection. Walking 8 feet at a normal pace of 3 m.p.h. takes 1.82 seconds. Walking time is not required for inspections performed on the stationary table.

Table 10. Test Results at 400 Head Per Hour Plant

Slaughter Rate - 400 head per hour
Conveyor Speed - 53.3 feet per minute

Inspection Method	[5]Time (sec) for Inspection
[6]Streamlined, without table	11.72
[6]Streamlined, with table	14.22

The concept of pacing relates how fast a person is working to how fast he or she is capable of working. People tend to fill the time allocated for accomplishing a task. They also tend to work faster as the work is speeded up. Pace values may be less than, equal to, or greater than 100 percent. In order to make fair comparisons of the time needed to inspect beef plucks, an allowance for the pace of the inspector needs to be made for each method. The measured, or raw time, is modified with the pacing allowance to calculate the standard time required to perform the inspection.

The inspectors' pace during the test was not determined. It is likely that it exceeded 100 percent rated speed for inspectors on the moving conveyor. If this is true, then the standard time for inspection on the moving conveyor would be increased.

Two additional inspector motions were involved with the use of the stationary table: (1) pulling the pluck off the conveyor; and (2) pushing it back on the conveyor. These additional motions add time to the inspection procedure. However, as was shown in table 8, approximately 27 seconds are available to perform the inspection, or three times as long as available with the old method.

The test showed that viscera inspection could be successfully performed off-line on a stationary table at very high speeds. Some difficulties with contamination and maintenance of identity of the organ sets marred the success of the test. Identification problems arose on those occasions when a heart/lung inspector wished to retain a carcass. The liver would be down a chute and thus out of reach by the time the heart/lung inspector completed his examination. A partial solution to these difficulties would be the use of stationary side tables by all the inspectors on the line, not just the one used in this test. This would add the same lag in all operations in the sequence, not just one. There are not the same number of liver inspectors as pluck inspectors. This means that the same lag will not occur in each operation. Thus, complete synchronization cannot be maintained even with this improvement.

Further Table Modifications

In the next test, radical changes were made in the design of the table. Modifications were made by removing all knee controls and replacing them with foot-operated ones. A drain was installed in the center of the work surface, and a perforated stainless steel plate was placed on top. An overhead hand-operated spray nozzle was added to allow cleaning of the table surface. Another gooseneck fixture was added for hand washing and connected to the foot controls. A splash guard was added to one side of the table to protect neighboring inspectors from being splashed. These modifications were not made under the supervision of the author, and are included in this report to show the effects of using a design of this type.

[5] Time values, provided by USDA-FSIS-IEDM-IEEB, do not include adjustments for pacing or time required for walk and return to original position

[6] Streamlined inspection refers to an inspection procedure which incorporates plant employees making the incisions that open the heart. This reduces the workload on government inspectors.

Test of Third Prototype Table

The test of the third off-line pluck inspection table took place in a 330 head-per-hour beef slaughter plant in Texas. The table was modified locally as noted above, installed in the middle of 3 pluck inspection stations, and used for approximately 3 weeks. A stool was provided in an effort to allow the inspector to work while seated. The cramped conditions in the plant necessitated locating the table parallel to the flight-top table. Traditional inspection procedure was used, with the inspectors making all cuts on the heart.

The inspector used his left hand to draw the pluck onto the table and his right to hold the knife and make incisions. After the inspection procedure was completed, the pluck was pushed gently back onto the conveyor. Then the table was cleaned with the hand-held spray nozzle. The hands could be washed on the table with a foot-operated gooseneck.

Several problems were associated with this experimental arrangement. Left-handed inspectors had a great deal of difficulty using the table at all. Cramped quarters in the inspection area made it difficult and sometimes even dangerous to enter and exit the work area. Sanitizing the work surface with the hand-held sprayer was an awkward, time-consuming task that often caused the inspector to rise from his or her chair, move into the path of oncoming carcasses, and sometimes get wet. Despite frequent cleaning of the table by the inspectors, tallow continued to build up on the table surface. This was probably because the perforated tabletop precluded the use of any type of continuous cleansing of the surface as was used in previous designs.

The time required to perform inspections varied considerably over the course of the test. Measurements for five different inspectors were made. The results, contained in table 11, are indicative of the trend reported previously of an increase in the amount of time required to perform the inspection when using the off-line inspection table.

Table 11.

Test Results of Third Prototype Table at 330 Head-per Hour

Slaughter Rate - 330 head per hour
Conveyor Speed - 44 feet per minute

Inspection Procedure	Time (seconds)
Traditional Inspection, (without table)	13-15
Traditional Inspection, (with table)	15-19

Poultry Inspection

Three types of inspection are currently in use in poultry processing plants: streamlined (SIS), new turkey inspection (NTI), and new line speed (NELS). Each system has its own line speed, equipment, and manning requirements. In this report, only the SIS and NELS systems will be discussed. Figure 3 shows a typical poultry inspection layout.

SIS

SIS inspection includes one or two inspectors depending on line speed. The work area for these inspectors requires at least 4 feet for the inspector and an additional 4 feet for the helper. (These distances refer to the linear distance along the evisceration line needed for inspection) The regulations require that the inspectors have adjustable platforms. The platforms must be at least 60 inches below the shackle at its lowest point and have at least 14 inches of vertical adjustment. The platforms themselves must be 48 inches long and at least 30 inches wide. They must come equipped with a 42-inch safety rail on the rear.

NELS

NELS inspection requires three viscera inspectors. Each inspector is teamed with two establishment employees, a presenter and a helper. The work station space requirements include 6 feet for the presenter, 4 feet for the inspector, and another 4 feet for the helper. These distances refer to linear distances along the evisceration line and are shown in figure 3. Kickouts 18 inches apart present every third bird to the inspector. The platforms on which the inspectors stand must be at least 4 by 2 feet, adjust at least 14 inches in height, and be no less than 60 inches below the shackle when adjusted to its lowest point. There must also be a safety rail 42 inches above the floor and a 1/2-inch toe rail around it.

Improved Poultry Inspection Equipment

Figure 4 shows some possible improvements in the design of poultry inspection platforms that could be applied to SIS or NELS plants. Widening the platform will allow the safer use of chairs. Building the platforms with chairs firmly attached to the platform increases safety by eliminating the possibility of falls from loose chairs that may slip off the platform. Increasing the amount of adjustability in height from 14 to 27 inches will allow both sitting and standing employees to perform their jobs properly. Putting shields on the edges of the platforms could prevent feet and limbs from being caught in a “scissors” type accident when the platform changes elevation. Properly mounted lights will increase visual acuity by eliminating glare.

Figure 3. Typical Poultry Inspection Layout

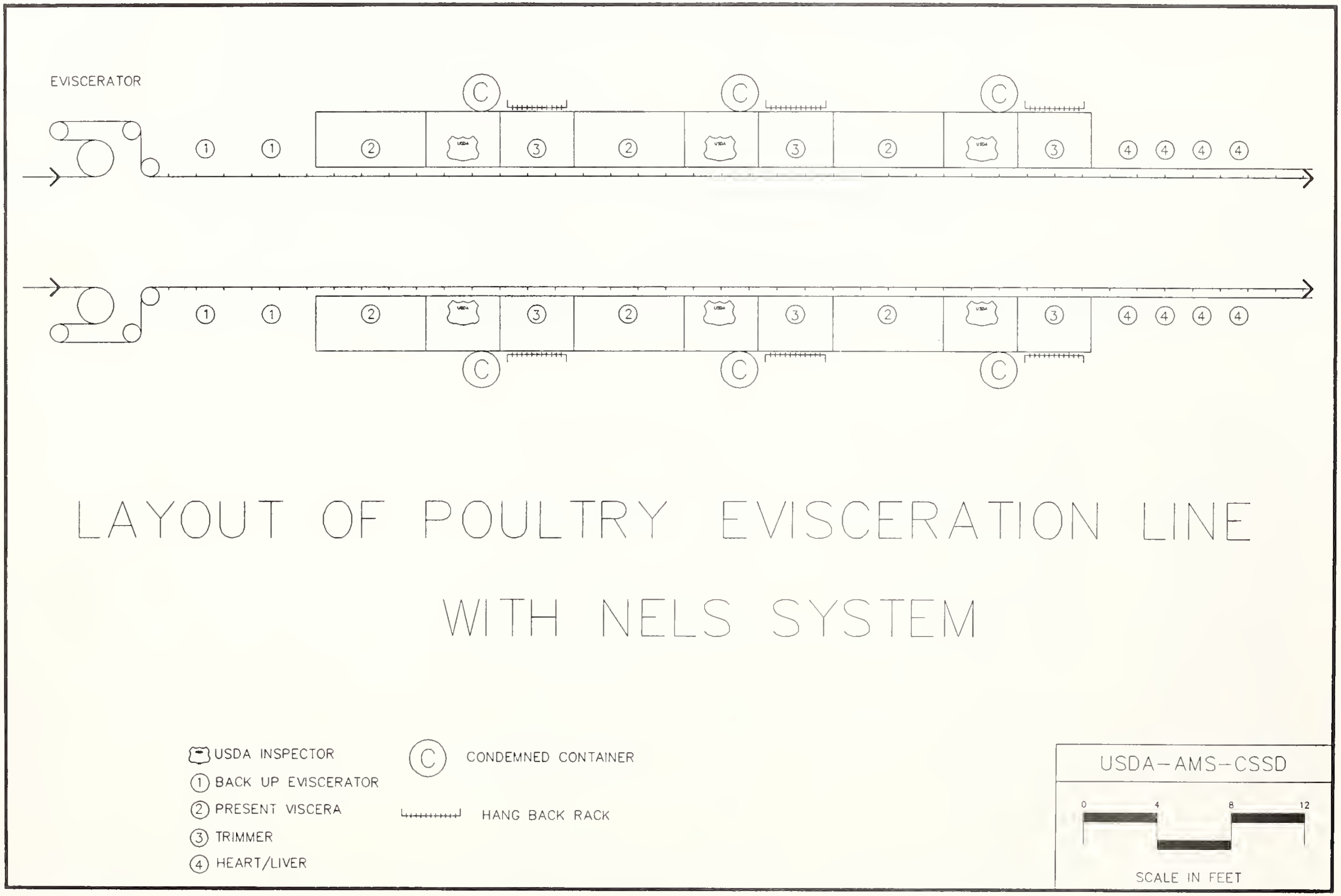
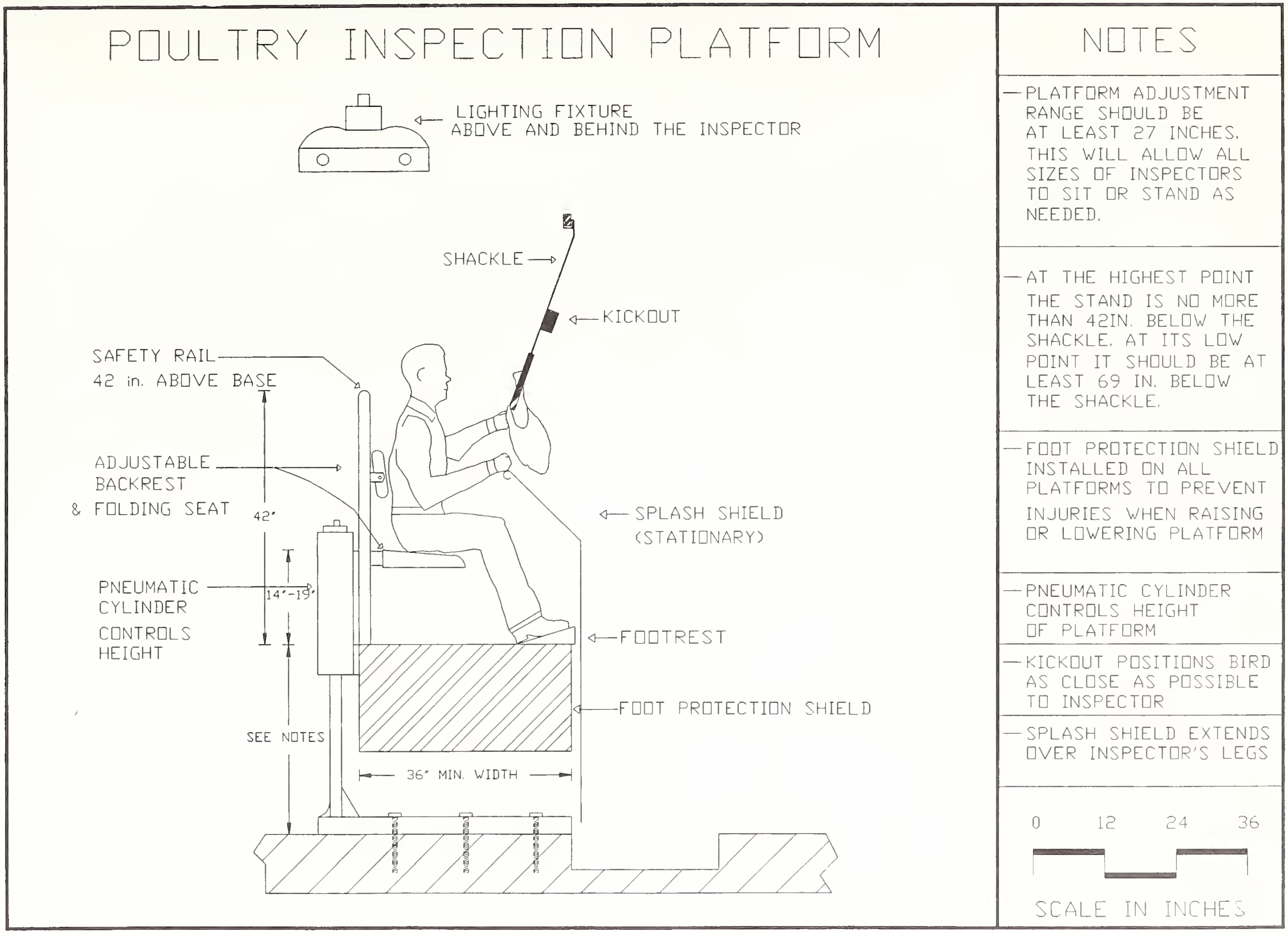


Figure 4. Improved Poultry Inspection Arrangement



Swine Inspection

Hog inspection in modern high-speed plants consists of inspection of head, viscera, and carcass. The number of inspectors at each position depends on the speed of production, the type and size of animals being slaughtered, and whether the head is inspected while attached to or detached from the carcass. This normally requires at least three inspection stations, one each for head, carcass, and viscera.

Viscera Inspection

The layout of a typical swine viscera inspection arrangement is shown in figure 5. Viscera inspection consists of the inspector(s) visually observing the heart, lungs, liver, and spleen in a moving pan. Eight feet of unobstructed linear distance along the processing line must be allocated for each viscera inspection station. The inspection pan or table is 34 inches above the inspector's platform. The platform is 3 feet wide and 8 feet long. A lavatory with hot water and towels must be located within easy reach of the inspector.

Head Inspection

Head inspection consists of the inspection of the animal's head in either the attached or detached condition. An inspection station 5 feet long and 3 feet wide is provided each head inspector. The elevation of the platform is determined by whether the head remains attached or detached from the rest of the carcass. The platform is 10 feet 9 inches below the carcass rail if the head remains attached and 8 feet 6 inches below the rail if the the head is detached. This elevation is generally not adjustable. Some suggestions for improving the design of these work areas are shown in figure 6. In addition to the required hand washing facilities, a knife sterilizer is required for each head inspector.

Carcass Inspection

Carcass inspection consists of visually inspecting the carcass for evidence of disease or condition that would make the swine unfit for human consumption. The inspection platform is 5 feet long by 3 feet wide and is 8 feet 6 inches below the top of the rail. This platform height is generally not adjustable. In addition a 5 by 5-foot mirror, about 3 feet behind the carcass, is mounted to allow a clear view of the rear of the carcass. As in the other inspection areas, a hand wash lavatory must be within easy reach of each inspector.

Figure 5. Typical Swine Viscera Inspection Layout

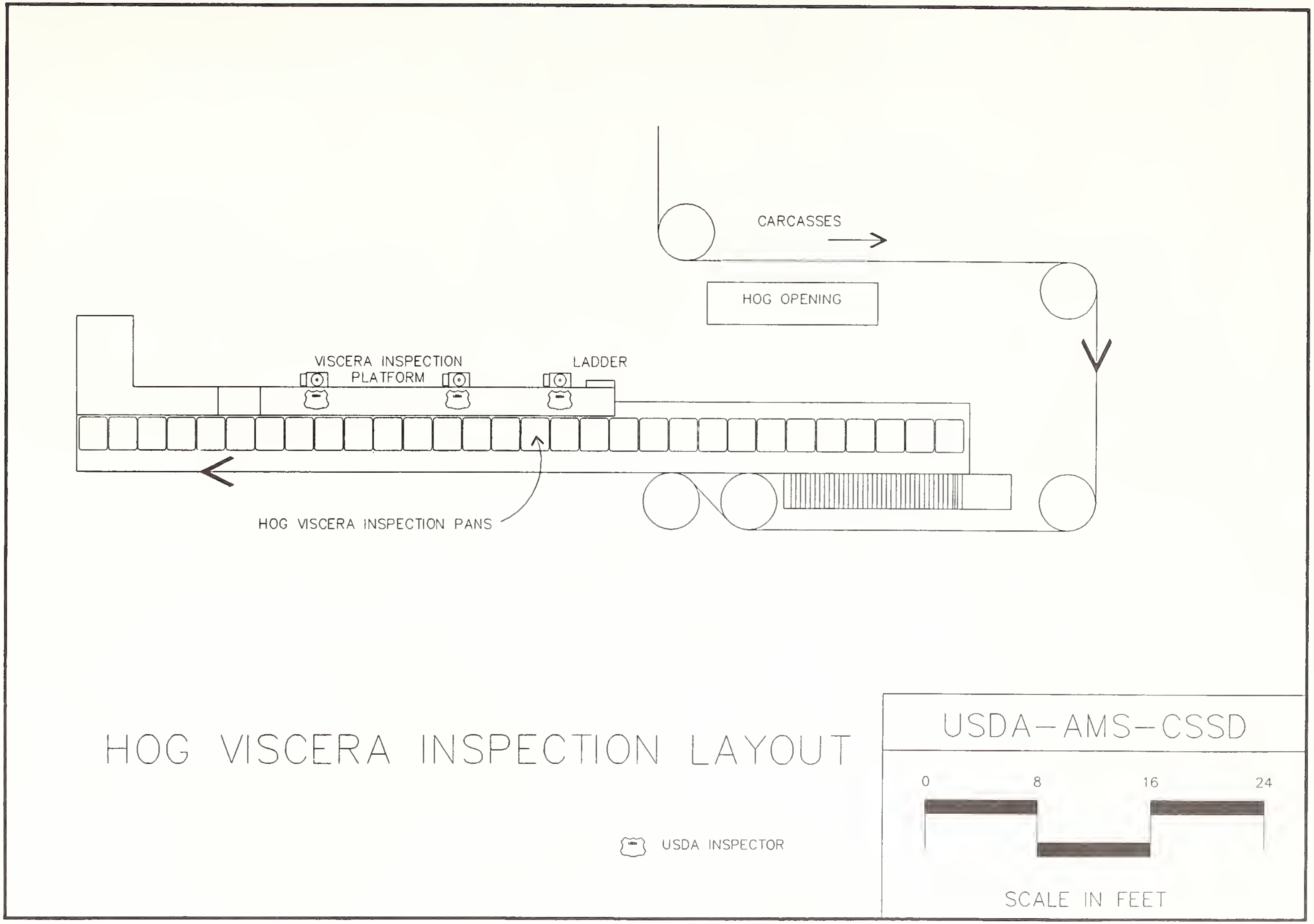
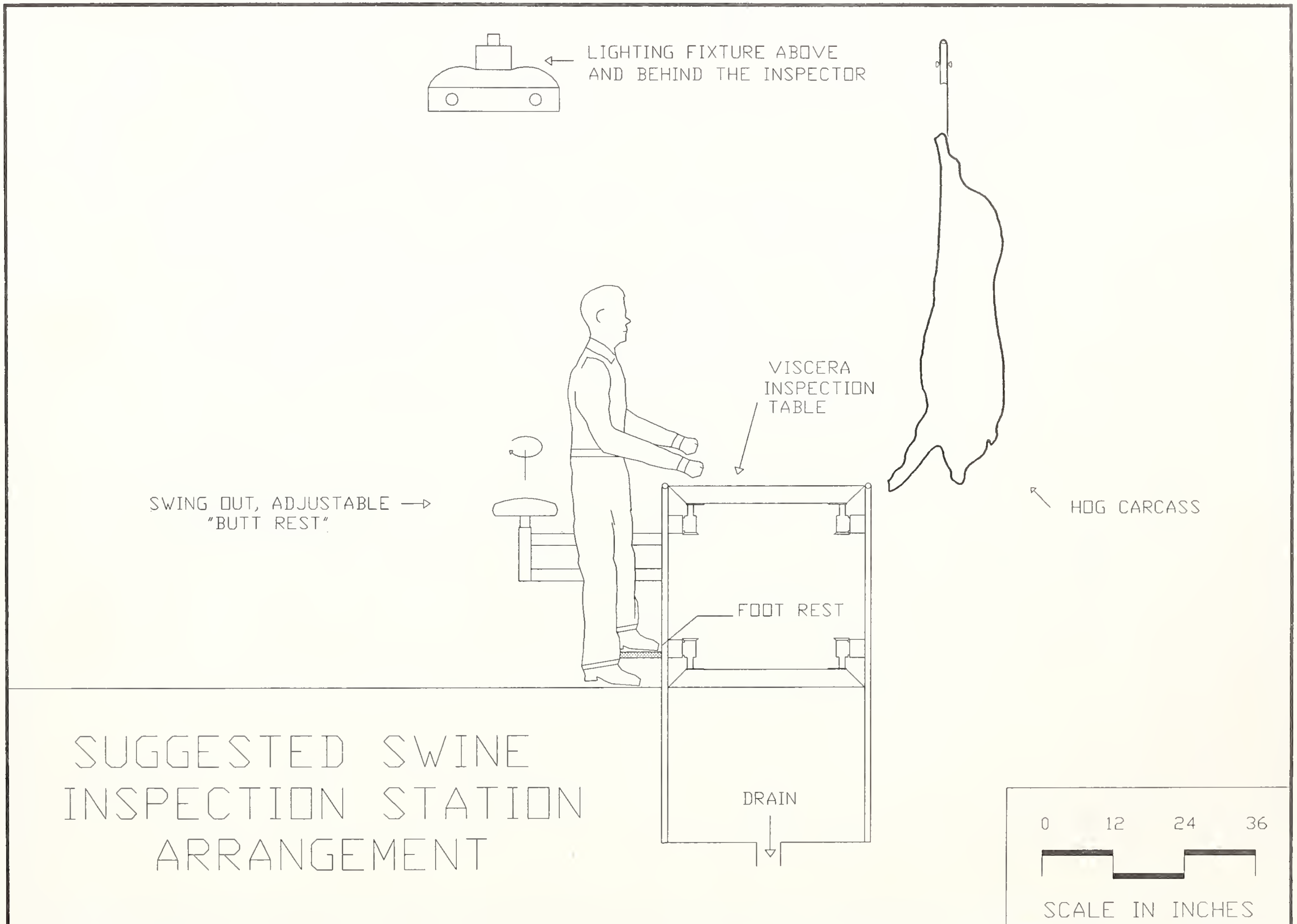


Figure 6. Improved Swine Inspection Station Arrangement



Conclusions

The following conclusions can be drawn from the results of the research reported here:

1) Improvement in the facilities and equipment used for meat and poultry inspection is needed.

2) Improvement in the mental health, physical health and work efficiency of meat inspectors should occur if the recommendations in this report are followed.

3) Inspection stations and equipment for inspectors in all species plants studied need to be made more adjustable so as to accommodate different sizes of individuals.

4) Work stations should be made adjustable to accommodate both sitting and standing positions whenever possible.

The tests of the off-line beef viscera inspection table indicated the following:

1) Beef plucks can be inspected with either traditional or streamlined inspection methods on the off-line table at speeds as great as 400 head per hour.

2) Wasted motion of inspectors walking along the viscera inspection conveyor would be eliminated by using the off-line table.

3) Time wasted by inspectors waiting for the arrival of a beef pluck would be eliminated by using the off-line table.

4) The amount of time required to perform the inspection increased when using the off-line pluck table.

5) Further development of the off-line pluck inspection table concept is necessary before implementation of the off-line table can be required by regulation.

6) The greatest obstacle to implementation is the difficulty in retaining identification of organs after inspection.

Recommendations for Further Research

The need for improvement to inspection facilities, stations, and equipment is great. The general recommendation is that the ideas, concepts, and design criteria in this report be integrated in the design of any new places of work. One important concept that needs to be promoted beyond all others is that of the work station. The work station is more than a place to work, it is an integration of all the good design elements from this report. The work station is a total environment that goes beyond satisfying the minimum requirements of a place where it is possible for a man or woman to perform his or her job. It encompasses the philosophy that work does not always have to be strenuous to be performed properly.

The work station concept as used here means the proper design of and provision for:

1) A chair to sit in while working;

2) A work surface of the proper height for each inspector;

3) A light source of proper quantity and quality, controlled by the inspector

4) A floor surface that is safe, comfortable, and in most cases adjustable;

5) A work environment cool and dry enough to allow proper concentration on the job without undue stress.

The specific applications of this design philosophy have included only the construction and testing of the off-line beef viscera inspection table. A short list of those work areas that could benefit from new equipment and facilities being implemented includes:

1) Head inspection for beef.
2) Head inspection for swine.
3) Poultry viscera inspection.
4) Swine viscera inspection.

Recommendations for further development of the off-line pluck inspection table are to:

1) add a second powered take-away conveyor that would move the inspected pluck to the next work station without danger of contamination.

2) add a mechanical flushing valve, similar to those used in commercial type commodes, to decrease the time needed to flush the table surface.

3) place adjustable platforms under each inspection station to adjust the height of the working surface to each individual's height.

4) develop a tagging system for each viscera set so that identification of all parts may be maintained for a longer period of time.

Selected Bibliography

[1] Abramowitz, A. Illumination. (part of) chapter 12 in: Baumeister, T., E.A. Avallone, and T. Baumeister III eds.. Mark's Standard Handbook for Mechanical Engineers. Eighth edition. McGraw-Hill, New York. 1979.

[2] ASAE. Lighting for Dairy Farms and the Poultry industry. ASAE engineering practice: ASAE epp344, in: 1981-82 Agricultural Engineers' Yearbook. ASAE, St. Joseph, MI.1981.

[3] ASHRAE. Handbook of Fundamentals. American Society of Heating, Refrigeration, and Air Conditioning Engineers. New York. 1981.

[4] Berney, G.E. and C.E. Harris. Improved Work Stations for Meat Inspectors. Paper No. 87-6055 presented at the 1987 ASAE Summer Meeting, Baltimore, MD. June 28 - July 1, 1987. ASAE, St. Joseph, MI. 1987.

[5] Brune, H.; Macias, R.; Wagner, N.; and R. Day. Task Force Report on Safety Footwear. USDA, Washington, DC. 1985.

[6] CFR. Food Safety and Inspection Service (meat,poultry), USDA. Combined Federal Regulations 9 CFR 200-, 1-1-87. U.S. Government Printing Office, Washington, DC. 1987.

[7] CFR. Food Safety and Inspection Service (meat,poultry), USDA. Combined Federal Regulations 9 CFR 200-, 1-1-88. U.S. Government Printing Office, Washington, DC. 1988.

[8] Dotson, C.O., Manny, P.D. and P.O. Davis. A Study of Occupational Stress among Poultry and Red Meat Inspectors. Final report for USDA-FSIS stress task force. Institute of Human Performance, Langley Park, MD. 1986.

[9] Esmay, M.L. Principles of Animal Environment (textbook edition). AVI, Westport, CT. 1978.

[10] Kaufman, J.E.(ed.) I.E.S. Lighting Handbook. Illuminating Engineers Society of North America, New York. 1981.

[11] NASA. Anthropometric Source Book (vol 1), Anthropometry for Designers (vol 2), A handbook of Anthropometric Data (vol 3). NASA reference publication 1024. NTIS, Springfield, VA. 1978.

[12] Schmidtke, H. Ergonomic Data for Equipment Design. Plenum, New York. 1984.

[13] USDA. Agricultural Statistics 1966. USDA, Washington, DC. 1966.

[14] USDA. Agricultural Statistics 1984. USDA, Washington, DC. 1984.

[15] USDA. U.S. Inspected Meat and Poultry Packing Plants, a Guide to Construction and Layout. Agriculture Handbook 570. USDA, Washington, DC. 1985.

[16] USDA. Agricultural Statistics 1986. USDA, Washington, DC. 1986.

[17] USDA. Report of Lighting Task Force Committee. USDA-FSIS, Washington, DC. 1986.

[18] Van Cott, H.P. and R.G. Kinkade. Human Engineering Guide to Equipment Design. U.S. Government Printing Office, Washington, DC. 1972.

[19] Vermeulen, D. Progress in Lighting, chapter 11 in: Fluorescent lamps and lighting. W. Elenbaas, editor. N.V. Philips, Eindhoven, Netherlands. 1959.

[20] Vernon, H. and T. Bedford. IFRB Report no.'s 39, 41, 62 as cited in: Human Performance in Industry. K. Murrell. Reinhold, London. 1965.

[21] Wilkes, B. and L. Stammerjohn. Job Demands and Worker Health in Machine-Paced Poultry Inspection. NIOSH, Cincinnati, Ohio. 1981.

[22] Woodson, W.E. Human Engineering Guide for Equipment Designers. University of California Press, Berkley, California. 1960.